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ABSTRACT:

A toe-cap for a safety shoe or boot is disclosed. In order to provide a toe-cap which is light and has sufficient strength, the toe-cap is made of a composite material comprising a fiber-reinforced thermoplastic resin (7) and at least one wire mesh (4) having a size of 7 to 200 meshes and embedded in the fiber-reinforced thermoplastic resin. In a preferred embodiment, the fiber-reinforced thermoplastic resin comprises a long-fiber reinforced thermoplastic layer (1) having reinforcing long fibers (5) incorporated therein and a short-fiber reinforced thermoplastic layer (2) having reinforcing short fibers (6) incorporated therein, and the wire mesh (4) is embedded in the short-fiber reinforced thermoplastic layer (2).

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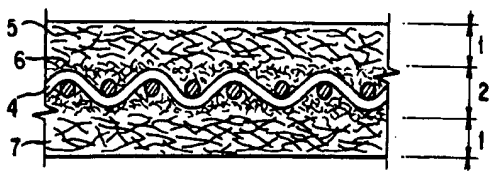
(54) Toe-caps for safety shoes.

(57) A toe-cap for a safety shoe or boot is disclosed. In order to provide a toe-cap which is light and has sufficient strength, the toe-cap is made of a composite material comprising a fiber-reinforced thermoplastic resin (7) and at least one wire mesh (4) having a size of 7 to 200 meshes and embedded in the fiber-reinforced thermoplastic resin. In a preferred embodiment, the fiber-reinforced thermoplastic resin comprises a long-fiber reinforced thermoplastic layer (1) having reinforcing long fibers (5) incorporated therein and a short-fiber reinforced thermoplastic layer (2) having reinforcing short fibers (6) incorporated therein, and the wire mesh (4) is embedded in the short-fiber reinforced thermoplastic layer (2).

FIG. 1



EP 0 614 623 A1

This invention relates to a toe-cap or boxtoe for use in safety foot wear such as shoes and boots (hereinafter referred to collectively as "shoe") to reinforce structurally the toe of a shoe and enhance the safety of the shoe.

Heretofore, the toe-caps of safety shoes made of steel have been exclusively accepted for actual use because of appreciation of the extreme importance of the strength of the uppers of safety shoes for protection of the wearer's toes against accidental heavy impact.

The safety shoes which use toe-caps made of steel, however, entail the problem of handicapping the wearer's mobility by an inevitable increase of weight of the safety shoes owing to the use of steel as the material for the toe-caps. Recently, for the sake of decreasing the weights of safety shoes, toe-caps having plastic layers superposed one each on both sides of a steel core member thereof have been proposed in published Japanese Utility Model Application, KOKAI (Early Publication) No. SHO 64-32609, for example.

The toe-caps having plastic layers superposed on a steel core member thereof, however, possibly fail to accomplish their object as a manufactured article because they are liable to entail interfacial separation between the steel core member and the plastic layers. Further, since these toe-caps are made of steel, their manufacture turns out to be a troublesome work. Moreover, the toe-caps have a large weight because their core members are made of steel.

In view of the problem encountered by the prior art as described above, the present invention aims to provide a toe-cap for a safety shoe which is light and so strong as to resist compression. More specifically, the present invention aims to provide a novel light toe-cap for a safety shoe which passes the standard for toe-caps for safety shoes [Japanese Industrial Standard (JIS) T 8101 "Safety Leather Shoes, Type S"].

These objects are attained by the toe-cap or boxtoe according to the present invention. According to the present invention, it is suggested that in a toe-cap for a safety foot wear having a domed shape adapted to lie over the toes of the wearer and an open end to receive the toes, the toe-cap is formed of a composite material comprising a fiber-reinforced thermoplastic resin and at least one wire mesh or woven metallic wire having a size of 7 to 200 meshes and embedded in the fiber-reinforced thermoplastic resin.

In carrying out the present invention in one preferred embodiment, the wire mesh is embedded in the central part of the fiber-reinforced thermoplastic resin in substantially parallel with the surfaces thereof. In another preferred embodiment, the wire meshes are embedded one each in opposite surface layers of the fiber-reinforced thermoplastic resin in substantially parallel with the surfaces thereof. Preferably the fiber-reinforced thermoplastic resin comprises a long-fiber reinforced thermoplastic layer having reinforcing long fibers incorporated therein and a short-fiber reinforced thermoplastic layer having reinforcing short fibers incorporated therein, and the wire mesh is embedded in the short-fiber reinforced thermoplastic layer.

In a preferred mode of the toe-cap according to the present invention, the toe-cap is formed of a composite material comprising (A) a short-fiber reinforced thermoplastic layer having reinforcing short fibers incorporated therein, (B) long-fiber reinforced thermoplastic layers lying one each in the opposite surface parts of the short-fiber reinforced thermoplastic layer and having reinforcing long fibers incorporated therein, and (C) a wire mesh having a size of 7 to 200 meshes and embedded in the aforementioned short-fiber reinforced thermoplastic layer.

In another preferred mode of the toe-cap according to the present invention, the toe-cap is formed of a composite material comprising (A) a long-fiber reinforced thermoplastic layer having reinforcing long fibers incorporated therein, (B) short-fiber reinforced thermoplastic layers lying one each in the opposite surface parts of the long-fiber reinforced thermoplastic layer and having reinforcing short fibers incorporated therein, and (C) wire meshes having a size of 7 to 200 meshes and embedded one each in the aforementioned short-fiber reinforced thermoplastic layers. Preferably the composite material further comprises skin layers made of a thermoplastic resin and lying one each in the outside surface parts of the aforementioned short-fiber reinforced thermoplastic layers.

Since the toe-cap according to the present invention is formed of a composite material comprising a fiber-reinforced thermoplastic resin and at least one wire mesh having a size of 7 to 200 meshes and embedded in the fiber-reinforced thermoplastic resin, it is light and so strong as to resist such high compression as more than 1,100 kg. Use of this toe-cap allows production of a safety shoe which gives the wearer comfortable mobility and highly reliable safe use.

Examples of the thermoplastic resin which is advantageously used as a matrix resin include, but are not limited to: nylon 6, polycarbonate (PC), polyethylene terephthalate (PET), polybutylene terephthalate (PBT), polyphenylene sulfide (PPS), and PBT/PC alloy.

The reinforcing fibers are glass fibers. The glass fibers fall under two types, short fibers and long fibers. The long fibers include random mat type fibers, woven fabric type fibers, and unidirectional mat type fibers. The short fibers have weak

strength. While the long fibers generally have sufficient strength, those of the woven fabric type and the unidirectional mat type have poor flowability and entail a problem of moldability and are at a disadvantage in necessitating a fabrication to be completed as a manufactured article aimed at. The present invention contemplates constituting a composite material comprising a glass-fiber reinforced thermoplastic resin and a wire mesh embedded therein in such a manner that short glass fibers are arranged near the wire mesh and long glass fibers are arranged in the other parts of the composite material. Owing to this arrangement, the glass fibers are allowed infallibly to enter the meshes of the wire mesh and consequently exalt the interlaminar strength.

The content of the glass fibers in the fiber-reinforced thermoplastic resin is desired to be in the range of 30 to 65% and the diameter of the individual glass fibers in the range of 9 to 13 μm. If the content of the glass fibers falls short of 30%, the insufficient supply of glass fibers will naturally prevent the fiber-reinforced thermoplastic resin and the toe-cap made predominantly thereof from acquiring sufficient strength. If the content of glass fibers exceeds 65%, the fiber-reinforced thermoplastic resin will be brittle. The excess supply of glass fibers, therefore, will put the composite material at a disadvantage in entailing degradation of elasticity and restoring force in spite of an increase in hardness and tending to break owing to concentration of compressive force.

The fiber-reinforced thermoplastic resin manifests the strength thereof more conspicuously when the diameter of the individual glass fibers is in the range of 9 to 13 μm. If the diameter of the individual glass fibers is smaller than 9 μm, since the glass fibers have a larger surface area for a fixed amount of glass fibers, the glass fibers will not be sufficiently wetted with the thermoplastic resin and the fiber-reinforced thermoplastic resin will fail to acquire high strength. Conversely, if the diameter of the individual glass fibers exceeds 13 μm, the fiber-reinforced thermoplastic resin will suffer from insufficient strength and brittleness.

The metallic materials which are effectively usable for the wire mesh include steel, stainless steel, and nickel, for example. For the sake of enhancing the tight adhesiveness of the fiber-reinforced thermoplastic resin with the wire mesh, it is recommendable to give the wire mesh a physical or chemical surface treatment. Concrete examples of the physical treatment include shot blasting and liquid honing which are intended to coarsen a given surface. Concrete examples of the chemical treatment include bonderizing treatment, chromic acid treatment, silane treatment, and zinc plating which are effective for a wire mesh made of steel. The chromic acid treatment, oxide film-forming treatment, etc. are available for a wire mesh made of stainless steel.

Now, the present invention will be described specifically below with reference to the accompanying drawings, wherein:

Fig. 1 is a model diagram of the cross section of one example of the composite material to be used for the manufacture of a toe-cap according to the present invention;

Fig. 2 is a model diagram of the cross section of another example of the composite material to be used for the manufacture of the toe-cap;

Fig. 3 is an explanatory diagram of one example of a process of manufacture of the composite material shown in Fig. 1;

Fig. 4 is an explanatory diagram of a process of manufacture of the toe-cap for a safety shoe by the use of the composite material according to the present invention;

Fig. 5 is a perspective view of one example of the toe-cap according to the present invention for use in a safety shoe;

Fig. 6 is a graph showing the relation between the mesh size of a wire mesh and the diameter of individual metallic wires forming the wire mesh required for obtaining prescribed strength; and

Fig. 7 is a graph showing the relation between the mesh size of a wire mesh used in a toe-cap and the compressive strength exerted on the toe-cap for a safety shoe.

Referring to the drawings, Fig. 1 illustrates one example of the composite material to be used for the toe-cap of the present invention. This composite material comprises a short-fiber reinforced thermoplastic layer 2 having reinforcing short fibers 6 incorporated in a thermoplastic resin 7, long-fiber reinforced thermoplastic layers 1 lying one each in the opposite surface parts of the short-fiber reinforced thermoplastic layer 2 and having reinforcing long fibers 5 incorporated in the thermoplastic resin 7, and a wire mesh 4 embedded in the short-fiber reinforced thermoplastic layer 2 disposed in the central part of the composite material.

Fig. 2 illustrates another example of the composite material. The composite material shown in Fig. 2 comprises a long-fiber reinforced thermoplastic layer 1 disposed in the central part thereof, short-fiber reinforced thermoplastic layers 2 lying one each in the opposite surface parts of the long-fiber reinforced thermoplastic layer 1, skin layers 3 made of the thermoplastic resin 7 and lying one each in the outside surface parts of the short-fiber reinforced thermoplastic layers 2, and wire meshes 4 embedded one each in the short-fiber reinforced thermoplastic layers 2.

In the composite material illustrated in Fig. 1 and in the composite material illustrated in Fig. 2 as well, short-fiber reinforced thermoplastic layers 2 are formed around each wire mesh.

Fig. 3 illustrates a process for manufacture of the composite material shown in Fig. 1. Platelike fiber-reinforced thermoplastic materials 8 each having a short-fiber reinforced thermoplastic layer 2 formed on the side confronting the wire mesh 4 and a long-fiber reinforced thermoplastic layer 1 formed on the other side thereof are opposed to each other across the wire mesh 4. When heat and pressure are simultaneously applied to the outer surfaces of the opposed fiber-reinforced thermoplastic materials 8 with the wire mesh 4 interposed therebetween, the short-fiber reinforced thermoplastic layers 2 are wrapped around the wires of the wire mesh 4 to give rise to a composite material having the wire mesh 4 embedded in the short-fiber reinforced thermoplastic layers 2 as illustrated in Fig. 1.

Production of a toe-cap for a safety shoe with the platelike composite material 9 is accomplished by cutting the platelike composite material 9 in the shape of a toe-cap for a safety shoe, setting the toe-cap workpiece in place in a female mould 10, lowering a male mould 11 to depress the workpiece against the female mould 10, and applying heat and pressure to the workpiece interposed therebetween, as illustrated in Fig. 4. Consequently, the toe-cap 20 for a safety shoe illustrated in Fig. 5 is obtained.

The toe-cap 20 has a domed shape conforming to the toe part of a safety shoe or boot so that, in use, it will cover the toes. The lower edge of the domed part 20a of the toe-cap 20 is provided with an inwardly directed integrally moulded skirt part 20b.

The strength of the toe-cap for a safety shoe is affected to a great extent by the properties of the wire mesh. If the wire mesh has a size of less than 7 meshes, for example, the total surface area of the wire mesh is unduly small without reference to the diameter of the individual wires of the wire mesh and the produced toe-cap fails to acquire prescribed strength. If the diameter of the wires of the wire mesh exceeds 620 μm, the adhesiveness of the wire mesh to the thermoplastic resin is insufficient and the produced toe-cap tends to sustain cohesive failure even when the wire mesh has a size of not less than 7 meshes. Conversely, if the wire mesh has a size of 200 meshes, the produced toe-cap fails to acquire the strength aimed at when the diameter of wires of the wire mesh is less than 40 μm.

Fig. 6 graphically illustrates a hatched area representing the relation between the mesh size of a wire mesh and the diameter of the individual wires of the wire mesh which was found to pass the standard strength 1,100 kg of compressive resistance (JIS T 8101, "Leather Safety Shoe, Type S") in an experiment performed on products using wire meshes of varying mesh sizes and varying wire diameters. In these products, the fiber-reinforced thermoplastic resin was nylon 6 resin containing 45% of glass fibers. For the wire mesh in these products, steel wires which had undergone a liquid honing treatment and then a chromic acid treatment were used.

Fig. 7 is a graph showing the relation between the compressive strength and the mesh size of the wire mesh actually observed in products using wire mesh whose relevant data fall within the hatched area of Fig. 6.

It is noted from the data of Fig. 7 that when the size of a wire mesh is less than 7 meshes, the total surface area of the wire mesh is unduly small and the strength of the produced toe-cap tends to betray fluctuation. If the diameter of the wires of the wire mesh exceeds 620 μm, the adhesiveness of the wire mesh to the resin is unduly low and the produced toe-cap tends to sustain cohesive failure even when the size of the wire mesh is not less than 7 meshes. Conversely, if the size of the wire mesh exceeds 200 meshes, the reinforcing fibers are no longer wrapped around the wire mesh and the produced toe-cap tends to induce ply separation. If the diameter of the wires of the wire mesh is less than 40 μm, the produced toe-cap fails to acquire sufficient strength even when the size of the wire mesh is 200 meshes.

From the foregoing detailed description, it will be evident that there are a number of changes, adaptations, and modifications of the present invention which come within the province of those skilled in the art. However, it is intended that all such variations not departing from the spirit of the invention be considered as within the scope thereof as limited solely by the claims appended hereto.

Claims

1. A toe-cap for a safety foot wear having a domed shape adapted to lie over the toes of the wearer and an open end to receive the toes, characterized in that the toe-cap (20) is formed of a composite material comprising a fiber-reinforced thermoplastic resin (7) and at least one wire mesh (4) having a size of 7 to 200 meshes and embedded in said fiber-reinforced thermoplastic resin.

2. A toe-cap according to claim 1, wherein said wire mesh (4) is embedded in the central part of said fiber-reinforced thermoplastic resin (7) in substantially parallel with the surfaces there-

of.

3. A toe-cap according to claim 1 or 2, wherein wire meshes (4) are embedded one each in opposite surface layers of said fiber-reinforced thermoplastic resin (7) in substantially parallel with the surfaces thereof.

4. A toe-cap according to claim 1, wherein said fiber-reinforced thermoplastic resin (7) comprises a long-fiber reinforced thermoplastic layer (1) having reinforcing long fibers (5) incorporated therein and a short-fiber reinforced thermoplastic layer (2) having reinforcing short fibers (6) incorporated therein, and said wire mesh (4) is embedded in said short-fiber reinforced thermoplastic layer (2).

5. A toe-cap for a safety foot wear having a domed shape adapted to lie over the toes of the wearer and an open end to receive the toes, characterized in that the toe-cap (20) is formed of a composite material comprising (A) a short-fiber reinforced thermoplastic layer (2) having reinforcing short fibers (6) incorporated therein, (B) long-fiber reinforced thermoplastic layers (1) lying one each in the opposite surface parts of said short-fiber reinforced thermoplastic layer (2) and having reinforcing long fibers (5) incorporated therein, and (C) a wire mesh (4) having a size of 7 to 200 meshes and embedded in said short-fiber reinforced thermoplastic layer (2).

6. A toe-cap for a safety foot wear having a domed shape adapted to lie over the toes of the wearer and an open end to receive the toes, characterized in that the toe-cap (20) is formed of a composite material comprising (A) a long-fiber reinforced thermoplastic layer (1) having reinforcing long fibers (5) incorporated therein, (B) short-fiber reinforced thermoplastic layers (2) lying one each in the opposite surface parts of said long-fiber reinforced thermoplastic layer (1) and having reinforcing short fibers (6) incorporated therein, and (C) wire meshes (4) having a size of 7 to 200 meshes and embedded one each in said short-fiber reinforced thermoplastic layers (2).

7. A toe-cap according to claim 6, wherein said composite material further comprises skin layers (3) made of a thermoplastic resin (7) and lying one each in the outside surface parts of said short-fiber reinforced thermoplastic layers (2).

8. A toe-cap according to any one of the preceding claims, wherein the diameter of wires of said wire mesh (4) is in the range of 40 to 620 μm.

9. A toe-cap according to any one of the preceding claims, wherein the content of said reinforcing fibers (5, 6) in the fiber-reinforced thermoplastic resin (7) is in the range of 30 to 65% and the diameter of said fibers is in the range of 9 to 13 μm.

10. A toe-cap according to any one of the preceding claims, wherein said reinforcing fiber (5, 6) is a glass fiber and said wire mesh (4) is a woven metallic wire which has undergone a surface treatment selected from the group consisting of shot blasting, liquid honing, bonderizing treatment, chromic acid treatment, silane treatment, zinc plating, and oxide film-forming treatment.

FIG. 1

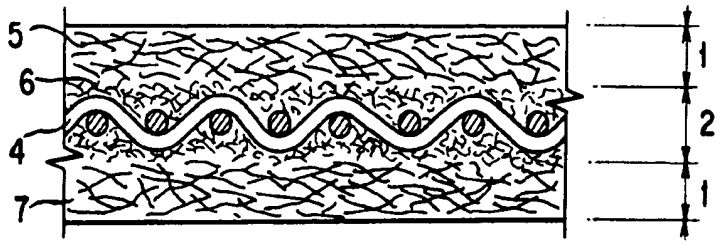


FIG. 2

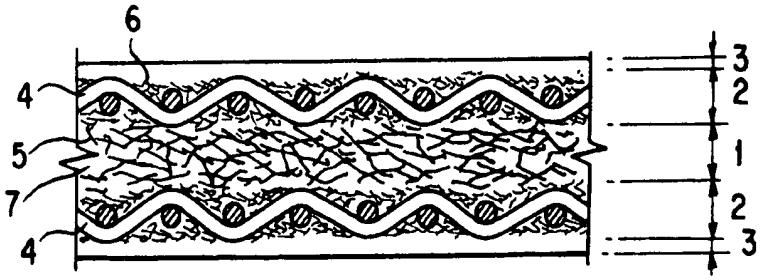


FIG. 3

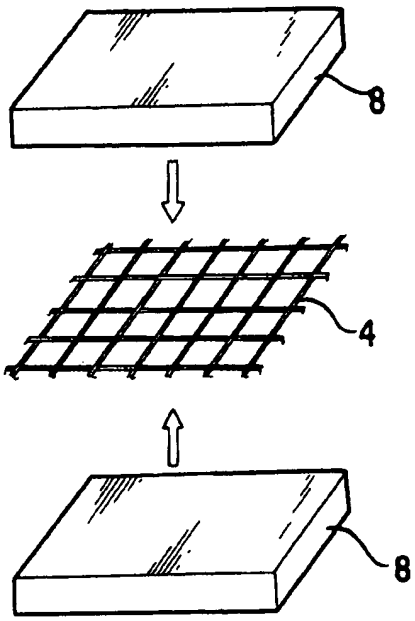


FIG. 4

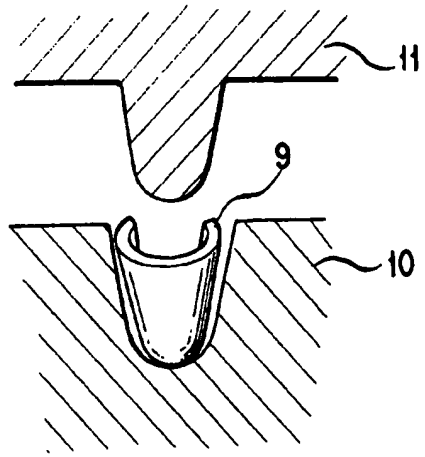


FIG. 5

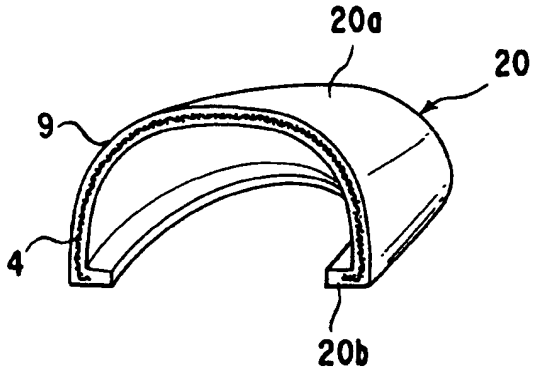
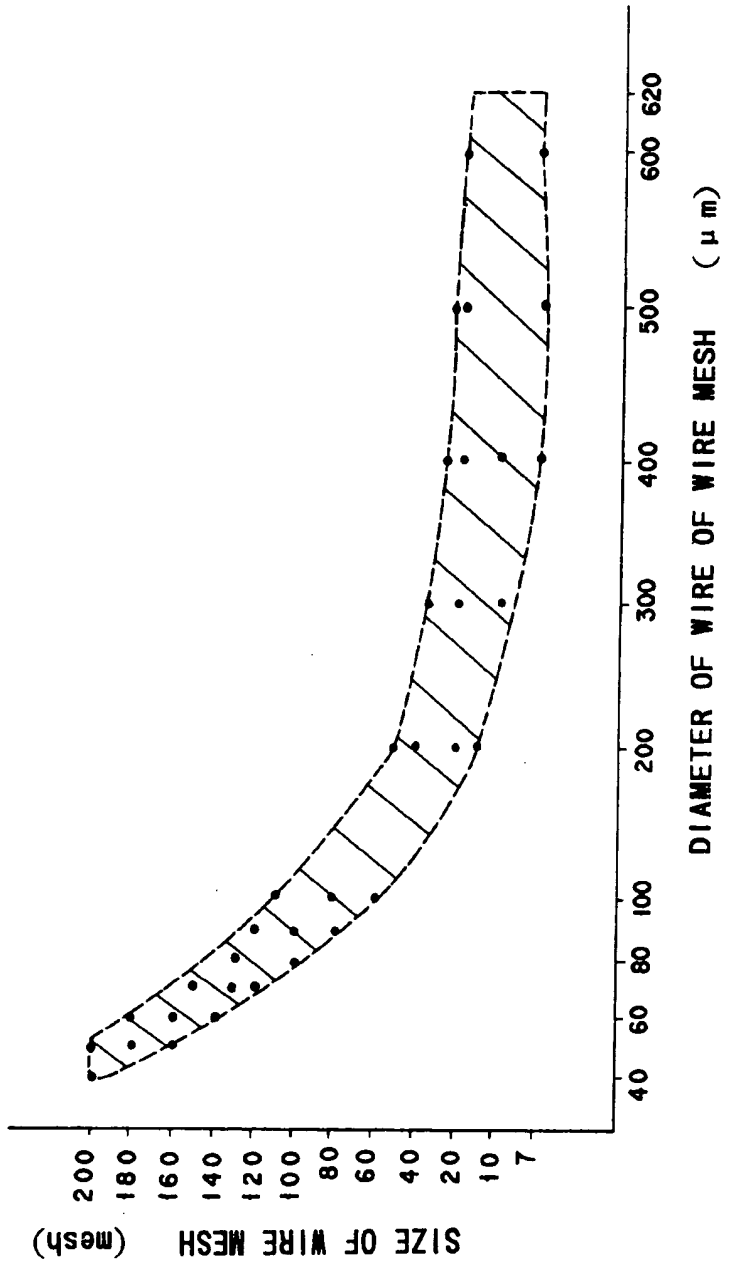


FIG. 6


SIZE OF WIRE MESH (mesh)
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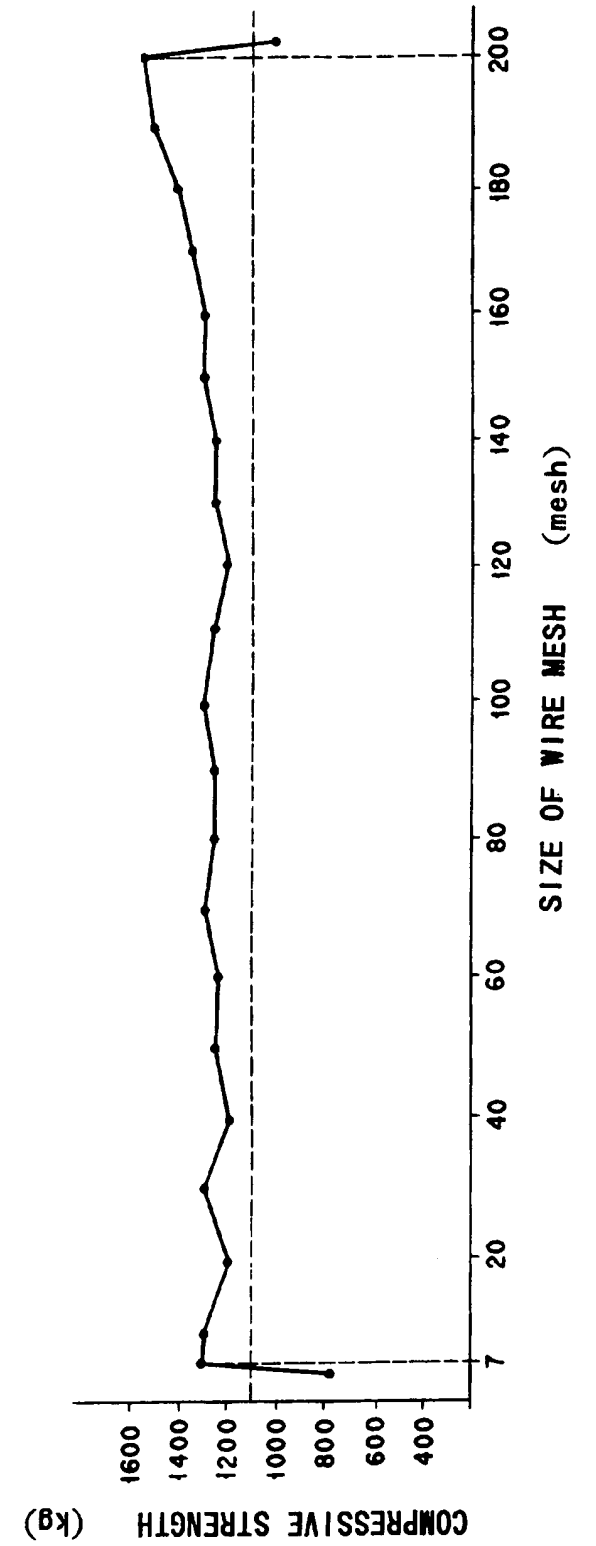
160
140
120
100
80
60
40
20
10
7
DIAMETER OF WIRE OF WIRE MESH (μm)
40
60
80
100
200
300
400
500
600
620

FIG. 7


COMPRESSIVE STRENGTH (kg)
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1400
1200
1000
800
600
400
7
20
40
60
80
100
120
140
160
180
200
SIZE OF WIRE MESH (mesh)

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EUROPEAN SEARCH REPORT

Application Number
EP 94 10 2424

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
X	EP-A-0 507 322 (YOSHIDA KOGYO) * the whole document *	1-9	A43B23/16
X	EP-A-0 102 414 (FOSS) * the whole document *	1-3,5,6	
X	GB-A-2 050 144 (LSB ORTHOPAEDICS) * the whole document *	1-3,5,6	
A	FR-A-2 572 259 (SOFREX) * the whole document *	1	
A	EP-A-0 100 181 (I.C.I) * the whole document *	1	

TECHNICAL FIELDS SEARCHED (Int.Cl.5)

A43B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	9 June 1994	Declerck, J

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